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TSUNAMI INUNDATION MODELING UPDATE FOR THE NORTHERN OREGON COAST: TILLAMOOK AND CLATSOP COUNTIES

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WHAT IS IN THIS REPORT?

This report corrects a bathymetric error identified in digital elevation models used in previous tsunami inundation modeling undertaken for Clatsop and Tillamook counties in 2013 for a Cascadia Subduction Zone earthquake (Mw 9.0). New inundation modeling is performed for the AKmax (distant) and XXL1 (local) tsunami scenarios; new inundation modeling is also performed for the L1 (local) tsunami for Clatsop County only.

Cover: Oblique view of the beach at Seaside showing high ground east of the beach.

Photo by D. Best, March 8, 2015.
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EXECUTIVE SUMMARY

This report corrects a bathymetric error identified in digital elevation models used in previous tsunami inundation modeling along the coast of Clatsop and Tillamook County, Oregon, in 2013 for a Cascadia Subduction Zone earthquake (Mw 9.0, XXL1) and maximum-considered distant tsunami (AKmax); new inundation modeling is also performed for the L1 (local) tsunami for Clatsop County only.

The report describes the identified grid errors observed in the original 2013 data and the steps taken to correct those errors. Development of an updated bathymetric/topographic grid that spans the northwestern Oregon Coast was undertaken by National Center for Environmental Information of the National Oceanic and Atmospheric Administration. Parameters used in the revised modeling are then presented and discussed. Finally, the report evaluates the observed changes between the original and latest tsunami modeling results for the coast of Clatsop and Tillamook counties.

With the completion of revised tsunami inundation simulations for both Clatsop and Tillamook counties, and following discussions with local emergency managers, the collective decision was to proceed with adopting the revised tsunami inundation maps in both counties. Assimilation of the revised inundation zones from Clatsop and Tillamook County has necessitated the release of an updated statewide tsunami evacuation geospatial layer for the Oregon Coast. Revised tsunami evacuation brochures are available through the Oregon Tsunami Clearinghouse (oregontsunami.org) and via the online tsunami evacuation portal (http://nvs.nanoos.org/TsunamiEvac) hosted by the Northwest Association of Networked Ocean Observing System and via the NVS Tsunami Evacuation Zones smartphone application.
1.0 INTRODUCTION

Tsunami inundation modeling updates are typically carried out for any one of the following reasons: improvements in the modeling physics, new or improved earthquake source information, new bathymetric and/or topographic data that are used to build digital elevation models (DEMs), or the need to address errors in past modeling. The objective of this report is to describe and document updated tsunami inundation simulations undertaken for both a maximum-considered Eastern Aleutian Island, Alaska (distant) and a Cascadia Subduction Zone (CSZ) (local) earthquake (Mw 9.0). These inundation simulations were originally modeled for Oregon’s Clatsop and Tillamook counties (Figure 1) between 2010 and 2013 (Priest and others, 2013). The need for revised tsunami inundation simulations in both counties was due to the discovery of several major bathymetric errors in the original model grids. Hence, this study corrects for those errors, documents differences between the original and revised modeling, and presents updated tsunami inundation maps for both counties.

The destructive and life-threatening forces of tsunamis are well known globally, as demonstrated by the 2011 Tōhoku, Japan, event that resulted in 15,899 killed and another 2,526 missing (as of March 10, 2021; National Police Agency of Japan, 2021) with most of the people having drowned in the tsunami. The Oregon Coast is similarly exposed to large subduction zone earthquakes, capable of generating catastrophic tsunamis (Walton and others, 2021; Witter and others, 2011). Verification for such events is recognized in the geologic record, with evidence of at least 19 earthquakes (>8.5 Mw) over the past 10,000 years (Goldfinger and others, 2017; Goldfinger and others, 2012; Nelson and others, 2020; Priest and others, 2009; Satake and others, 2003; Walton and others, 2021; Witter and others, 2012). The most recent major earthquake occurred 321 years ago on January 26, 1700 (Atwater and others, 2005). Goldfinger and others (2017) estimated the conditional probability of an earthquake on the CSZ at ~16% to 22% in the next 50 years; a partial rupture of the CSZ impacting the southern Oregon Coast has a conditional probability of ~37% to 43% (Goldfinger and others, 2017).

Due to the grave risk posed by a Cascadia tsunami striking the Oregon Coast, with potentially many thousands of lives lost, the Oregon Department of Geology and Mineral Industries (DOGAMI) initiated a multiyear effort beginning in 2010 to generate coastwide tsunami inundation maps. This effort was funded by the National Weather Service of the National Oceanic and Atmospheric Administration (NOAA) through the National Tsunami Hazard Mitigation Program (NTHMP) and was completed in June 2013. The modeling focused on the following seven deterministic scenarios (Priest and others, 2013; Witter and others, 2011):

- Two Gulf of Alaska distant earthquake sources, termed AK64 after the historical 1964 Prince William Sound earthquake, and a maximum-considered eastern Alaska-Aleutian Island rupture termed AKmax; and,
- Five locally generated earthquake scenarios occurring on the CSZ, termed small (SM1), medium (M1), large (L1), extra-large (XL1), and extra-extra-large (XXL1).

The original modeling undertaken by Witter and others (2011) and Priest and others (2013) was performed using detailed bathymetric and topographic grids that integrated high-resolution lidar data collected by DOGAMI in 2008-2009, best available bathymetric information determined from NOAA tsunami grids, modern surveys of navigation channels provided by the U.S. Army Corps of Engineers, and where available, local surveys of select coastal estuaries. These data were adjusted to the Mean Higher High Water (MHHW) vertical datum— the average of the higher high water height of each tidal day
observed over the National Tidal Datum Epoch, which covers the period 1983-2001\(^1\) —and then compiled into a DEM. Thirteen computational grids used for the tsunami simulations were subsequently constructed by retrieving from the DEM elevations at a series of points defining a triangular irregular network (Priest and others, 2013). Grid spacing in the grids differed from the detailed DEM in order to minimize computing time while accurately simulating important bathymetric and topographic features controlling tsunami propagation and inundation (e.g., offshore banks and canyons, abrupt changes in slope, jetties, breakwaters, and channels). Tsunami simulations were completed, and modeled inundation zones extrapolated. With the completion of the tsunami inundation modeling, the results were shared with coastal communities through a Tsunami Advisory Council (Witter and others 2011; Priest and others, 2013). Based on feedback from emergency managers, first responders, and community leaders, the council ultimately adopted a two-zone tsunami evacuation map that consisted of a maximum-considered distant (AK\(_\text{max}\)) and a local (XXL) tsunami.

Since completing coastwide modeling, DOGAMI staff have organized the original 8 terabytes of modeling data, while also undertaking new evacuation modeling, to better guide the public out of the inundation zone (Gabel and Allan, 2017; Gabel and others, 2020; Priest and others, 2015), as well as new maritime modeling for select ports and harbors (Allan and others, 2018; Allan and others, 2020). An outcome of these latest modeling efforts has been a move toward developing seamless coastwide tsunami products from the original modeling data, beyond the inundation zone layers provided on the standard evacuation maps (http://nvs.nanoos.org/TsunamiEvac) or tsunami inundation map series (https://www.oregongeology.org/tsuclearinghouse/pubs-inumaps.htm). These coastwide layers include rasters of the earthquake fault source used to trigger the tsunami, tsunami flow depths, current velocities and runup heights, digital elevations of the simulation grids, and point data for the complete suite of simulations, enabling such data to be easily accessed and queried.

Between 2016 and 2018, Allan and others (2018) completed new tsunami inundation modeling for the Columbia River estuary system, which included updated bathymetric and topographic data derived from a variety of sources, including the U.S. Army Corps of Engineers and NOAA. The results from that effort allowed us to evaluate these latest inundation modeling results and compare them with similar products completed as part of the 2010-2013 modeling described in Witter and others (2011) and Priest and others (2013). In undertaking such comparisons, several computational grid errors in the 2013 model grid were discovered offshore of the Clatsop Plains that reflected a shallower bathymetry when compared with the newer grid used in the 2018 Columbia River modeling (Allan and others, 2018). Comparisons of the tsunami simulation results (original versus new) suggested generally less inundation. A similar evaluation of the original grid DEMs was undertaken for the rest of the Oregon Coast. Based on this assessment, we identified a more substantive grid problem offshore from Tillamook County (between Cape Lookout and Rockaway Beach). Because the tsunami simulations are sensitive to the underlying bathymetry, the decision was made to undertake new modeling of both counties to evaluate the effects of those grid errors, and if warranted, produce updated evacuation maps.

For the purposes of this report, we initially present the characteristics of the earthquake source parameters in Section 0 before describing the hydrodynamic modeling used to simulate the latest tsunami inundation results. A comparison of the latest modeling results with those originally generated in 2013 is examined in Section 3.0, followed by a discussion of the updated tsunami zones.

\(^1\)https://tidesandcurrents.noaa.gov/datum_options.html
Figure 1. Location map of the Cascadia Subduction Zone, coastal cities on the Oregon Coast, and project area highlighted in blue.
2.0 METHODS

Between 2009 and 2013, DOGAMI staff implemented a comprehensive effort to model and map tsunami inundation zones for the entire Oregon Coast (Priest and others, 2009; Priest and others, 2013; Witter and others, 2011). Modeling of the various earthquake scenarios eventually settled on two Gulf of Alaska distant source scenarios and five locally generated earthquake scenarios occurring on the CSZ. Here we briefly define the characteristics of the earthquake source parameters before describing the hydrodynamic model used to simulate tsunami inundation.

2.1 Distant Earthquake Sources

Priest and others (2013) and Witter and others (2011) defined two distant earthquake sources (Mw ~9.2) for maximum-considered tsunamis originating on the eastern part of the Alaska-Aleutian subduction zone. Scenario AK64 reflects the historical 1964 Prince William Sound earthquake, which produced the largest distant tsunami to reach the Oregon Coast in the written historical record. Simulations of this event were primarily used to provide quality control against known observations of water levels and tsunami wave runup identified at various Oregon Coast locations, enabling validation of the hydrodynamic model—the Semi-implicit Eulerian-Lagrangian Finite Element (SELFE) model—used to simulate tsunami inundation (Priest and others, 2009; Zhang and others, 2011).

A hypothetical maximum-considered event originating near the 1964 event was also modeled. This second scenario termed AKmax is identified as “Source 3” in Table 1 of González and others (2009); more detailed information describing the earthquake parameters is provided in TPSWG (2006). The AKmax fault model reflects a distributed slip source on 12 subfaults, with each subfault assigned an individual slip value of 49, 66, 82, and 98 feet (15, 20, 25 and 30 meters). These extreme parameters result in maximum seafloor uplift that is nearly twice as large as the uplift produced by the 1964 Prince William Sound earthquake estimated by Johnson and others (1996). Examination of the modeled tsunami amplitudes simulated for this source indicate beams of high energy directed more efficiently toward the Oregon Coast (González and others, 2009) when compared with other Alaska-Aleutian subduction zone sources. Accordingly, the hypothetical Gulf of Alaska scenario was used by DOGAMI as the maximum-considered distant tsunami source for modeling a far-field tsunami for the Oregon Coast.

For this study, we decided to only re-model the AKmax scenario because it was unclear to what the degree changes in the local bathymetry would have on the distant tsunamis, and because the AKmax scenario is used in the statewide tsunami evacuation maps and hence has life safety importance.

2.2 Local Earthquake Sources

Priest and others (2009) and Witter and others (2013) described a range of plausible CSZ earthquake sources for the Oregon Coast, guided by CSZ geometry and tectonic behavior (Hyndman and Wang, 1995; McCaffrey and others, 2007; McCrory and others, 2004; Mitchell and others, 1994). These data were calibrated against paleoseismic records derived from coastal estuaries and lakes that document the impacts of as many as 13 major subduction zone earthquakes and associated tsunami over the past ~7,000 years (Kelsey and others, 2005; Walton and others, 2021; Witter and others, 2003). In addition, studies of turbidite records within sediment cores collected in deep water at the heads of Cascadia submarine canyons provide evidence for at least 19 full-margin ruptures and accompanying tsunami over the past ~10,000 years (Goldfinger and others, 2003; Goldfinger and others, 2012). Fault slip was
assumed to be approximately equal to the plate convergence (i.e., coupling ratio = 1.0, (Scholz and Campos, 2012)), and that variation in time intervals between offshore turbidites are representative of variations in coseismic slip that are proportional to the size of the generated tsunami (Priest and others, 2009; Priest and others, 2013).

The earthquake scenarios used to model tsunami inundation for the Oregon Coast reflected full-length ruptures of the CSZ and the corresponding surface deformation used for tsunami simulations (Witter and others, 2013). This was necessary since the primary purpose of the original effort was directed at the development of regional tsunami inundation maps. Three representative slip models were evaluated: 1) slip partitioned to a hypothetical splay fault (i.e., M1, L1, etc.) in the accretionary wedge; 2) a shallow earthquake rupture model (i.e., M2, L2, etc.); and 3) a deep rupture model (i.e., M3, L3, etc.). After evaluating the suite of potential slip models and modeling results, Witter and others (2011) recommended using the hypothetical splay fault model for generating coastwide tsunami inundation maps since that slip model yielded the most conservative tsunami inundation results.

Intervals that separate the 19 sandy turbidites range from as little as ~110 years to as long as ~1,150 years (Table 1 in Goldfinger and others, 2012). Based on these data, select time intervals (mean values rounded to the nearest quarter century) were defined as representative of four general earthquake size (also referred to as t-shirt) classes:

- **small (SM):** means the average time between events is 300 years (range=~110 to 480 years, 5 events). Recurrence for SM is estimated at 1/2,000 years;
- **medium (M):** means the average time between events is 525 years (range=~310 to 660 years, 10 events). Recurrence for M is estimated at 1/1,000 years;
- **large (L):** means the average time between events is 800 years (range=~680 to 1,000 years, 3 events). Recurrence for L is estimated at 1/3,333 years; and,
- **extra-large (XL):** means the average time between events is 1,150 years (1 event), rounded to 1,200 years. Recurrence for XL is estimated at <1/10,000 years.

The mean recurrence interval multiplied by the CSZ plate convergence rate at each latitude equals the amount of slip deficit released in each earthquake scenario (Priest and others, 2013). Slip was also reduced progressively from north to south on the CSZ (Priest and others, 2013) to account for evidence in the paleoseismic record of increasing numbers of partial CSZ ruptures from north to south (Goldfinger and others, 2012; Witter and others, 2013). A fifth scenario termed extra-extra-large (XXL) simulated a maximum-considered tsunami, which would be used to guide evacuation planning (Witter and others, 2013). This last hypothetical scenario assumes 1,200 years of slip deficit release but without any reduction (tapering) of slip from north to south; recurrence for the XXL event is not known. Modeling was undertaken and the results were summarized on maps depicting the percent confidence that the local CSZ tsunami will reach no farther inland than each inundation line. Hence, the five t-shirt earthquake sizes have the following confidence levels: SM1 = 25%, M1=79%, L1 = 95%, XL1 = 98%, and XXL1 = 100%. Of these, the M1 scenario has the highest likelihood of occurrence (Witter and others, 2011; Witter and others, 2013).

For the updated mapping undertaken here, we focused our attention on those scenarios used specifically for evacuation planning purposes. To that end, new modeling using the same earthquake source and slip models was undertaken for the AKmax, L1 and XXL1 (hereon referred to as L or XXL) scenarios in Clatsop County and the AKmax and XXL scenarios for Tillamook County. Ideally, future modeling could eventually update all earthquake scenarios, thus allowing for the complete suite of scenarios for the tsunami inundation maps to be updated. However, due to limited funding, this was not possible.
2.3 Tsunami Simulation

Simulations of tsunami propagation and inundation undertaken between 2010 and 2013 used the hydrodynamic finite element SELFE model (Priest and others, 2010; Witter and others, 2012; Zhang and Baptista, 2008a; Zhang and Baptista, 2009b; Zhang and others, 2011)). Algorithms used to solve the Navier-Stokes shallow water equations in these models are computationally efficient and stable. SELFE passed all standard tsunami benchmark tests (Zhang and Baptista, 2008a) and closely reproduced observed inundation and flow depths of the 1964 Alaska tsunami in a trial at Cannon Beach (Priest and others, 2009; Priest and others, 2010; Zhang and others, 2011).

The original SELFE hydrodynamic model has been replaced by SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model, [SCHISM wiki](http://www.ngdc.noaa.gov/mgg/schism.wiki), (Zhang and others, 2016b)). SCHISM is similar to SELFE but has added modular functionality. Most recently, SCHISM successfully passed a suite of standardized tsunami current benchmark tests organized via the Mapping and Modeling Subcommittee of the NTHMP (Lynett and others, 2017; Zhang and others, 2016a).

Both SELFE and SCHISM use an unstructured finite element mesh grid for hydrodynamic modeling, important for accurately simulating geomorphic features that are likely to influence tsunami propagation and inundation (e.g., offshore banks and canyons, abrupt changes in slope, jetties, breakwaters, and channels).

Thirteen computational grids were developed as part of the original coastwide modeling. These grids were constructed by first compiling DEMs covering five different model regions of the Oregon Coast and then extracting from the DEM, elevations at a series of points defined by the triangular irregular network. The DEM for the regional simulations was compiled from ETOPO1 1-arc-minute (~1.2 mi (1.9 km)) database ([http://www.ngdc.noaa.gov/mgg/global/global.html](http://www.ngdc.noaa.gov/mgg/global/global.html)) and 1/3-arc-second (~33 ft (10 m)) tsunami grids obtained for each region (Astoria, Garibaldi, Central and Port Orford) and obtained from the National Center for Environment Information (NCEI, formerly National Geophysical Data Center), supplemented in areas of dry land by 2008/2009 lidar (light detection and ranging) data. All datasets were adjusted to the North American Vertical Datum of 1988 (NAVD 88) and WGS 84 map projection. Computational grid spacing for tsunami simulations varied from ~1.9 to 3.1 mi (3 to 5 km) at the CSZ source, ~459 ft (140 m) at 230 ft (70 m) deep, and ~164 ft (50 m) at 66 ft (20 m) deep, to ~23 ft (7 m) at the coast and on land (Priest and others, 2010). A typical grid thus consists of ~5 million horizontal nodes and ~10 million triangular elements.

Vertical components of seabed deformation from the earthquake rupture were used to setup the initial water surface for the tsunami simulations as well as the initial velocity, assuming a short (10 seconds) initial constant acceleration of the seafloor and using a 1 second time step. The simulations were performed using only one layer in the vertical, such that the modeling is 2D depth averaged. This is consistent with the majority of existing tsunami inundation modeling efforts presently being implemented by NTHMP partner states and territories. Each simulation was run for about eight hours, providing sufficient time for the tsunami to run its course. In all cases, the simulations were run at MHHW, which varied slightly along the coast depending on the nearest tide gage to the model grids (e.g., Astoria on the north coast = 6.9 ft (2.11 m NAVD88), whereas Port Orford on the south coast = 6.8 ft (2.07 m)). Since the overall objective of the study was to produce inundation zones that would be conservative enough for defining statewide evacuation zones, the modeling used zero-bottom friction (i.e., Manning’s n = 0). Titov and Synolakis (1997) note in their review that inundation results are not particularly sensitive to changes in roughness coefficient (i.e., bottom friction).

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2.4 Revised Tsunami Simulations

For the tsunami inundation modeling presented here, we replicate the original approach of Priest and others (2013) with the only difference being the updated DEM and revised tsunami grid. For the DEM, we worked with NCEI to build an entirely new digital elevation model for all of Tillamook and Clatsop counties at a resolution of 1/9 arc-second (~10 ft (3 m)) (Carignan and others, 2019). The new grid represents the best available information at the time of their creation. Digital data used in developing the new DEM reflect a variety of data sources, including: U.S. Geological Survey (USGS); U.S. Army Corps of Engineers (USACE, includes both surveys in the navigational channels and topographic-bathymetric (topobathy) lidar); NOAA Office of Coastal Management; NOAA NCEI; and lidar collected by the State of Oregon. Additional information on development of the updated Clatsop-Tillamook DEM may be found in Carignan and others (2019).

Figure 2 and Figure 3 provide maps and cross section information that highlight the changes in the DEMs undertaken for both counties. These include the original 2013 DEM (Figure 2A and Figure 3A) and the recently updated 2020 DEM developed for Tillamook (Figure 2B) and Clatsop County (Figure 3B) respectively. Figure 2C and Figure 3C present a difference map showing the absolute change in the topobathy elevations between 2013 and 2020, along with three representative cross section plots (Figures 2 and 3, D-F) showing the actual cross-shore differences in greater detail. In general, dark blue colors shown in Figure 2C and Figure 3C indicate those areas in which the change in elevation is generally negligible (<3.3 ft (<1 m)), while yellows to reds highlight areas that have undergone more substantive change (> 13 ft (>4 m)).

As can be seen in Figure 2 for Tillamook County, the area that experienced the largest elevation change is concentrated between the inner continental shelf and nearshore, with the areas of greatest change identified by the yellow polygon. Figure 2D to 2F highlight the cross-shore profiles at three representative transect locations derived for Tillamook County; the upper plot reflects the actual cross section showing the change in elevation/water depth with distance from the shore, while the lower plot is the difference in elevation between the two DEMs. Apparent from the cross sections, the original 2013 DEM (solid black line) was characterized by an anomalous mound in about 131 to 164 ft (40 to 50 m) water depth along much of the coast off Tillamook County. This is most apparent offshore from Tillamook Bay (Figure 2E) and northward toward Manzanita (Figure 2F), where the mound attains heights of 33 to 49 ft (10 to 15 m), and widths of ~3,300 ft (1,000 m) wide. In contrast, the updated DEM (solid red line) corrects for those errors while also reducing some additional noise present in the original DEM. Differences between the two DEMs in the nearshore zone (<66 ft (<20 m)) are likely real due to the inclusion of updated (2016) topobathy lidar that is able to penetrate the water column to capture the seabed below. The topobathy lidar can capture, in particular, the presence or absence of nearshore sandbars that can be identified close to the beach.

Offshore Clatsop County (Figure 3), the areas that experienced the largest elevation changes include: a large area > 9.3 mi (15 km) west of the central Clatsop Plains at about mid-shelf; between the inner shelf and coastline (< 3.1 mi (5 km) from the coast), with the areas of greatest change occurring adjacent to Gearhart, Seaside, and offshore Tillamook Head. Additional improvements occur farther south offshore from Cannon Beach and Arch Cape. As can be seen in the cross sections, the original 2013 DEM (solid black line) was characterized by an anomalous step (~10 ft (3 m) high) in the bathymetry in about 66 to 131 ft (20 to 40 m) water depth. This step is most obvious in Figure 3A and is typically ~2.5 mi (~4 km) from the Clatsop shoreline. However, by the far the greatest improvements to the DEM occur well offshore the central Clatsop Plains and down by Gearhart and Seaside.
Improvements to the DEM are also apparent for each of the Tillamook estuaries (Figure 2C), where the latest bathymetric updates have resulted in better delineation of the estuary channels and water depths. These changes are due to the recent inclusion of topobathy lidar (e.g., 2016), local surveys, and navigational channel surveys. In the absence of bathymetric data in many of the estuaries, Priest and others (2013) used professional judgment to estimate potential water depths between the shoreline and those areas where they had bathymetric data. In these data gaps, a default depth of 10 ft (3 m) was assumed below the lidar-defined estuarine water elevation, with smoothing between this depth and those adjacent areas that had measured depths. Hence the 2020 DEM developed by NCEI addresses this deficiency where feasible. However, it should be recognized that even in the most distal areas of many estuaries, as well as upriver channels, accurate measurements of the estuary or riverbed are not available. For these areas, care was taken by NCEI staff to ensure the DEMs were hydro-flattened.
Figure 2. Digital elevation model changes determined for Tillamook County.

A) Original 2013 model grid with yellow polygon that defines the region where the bathymetric error is greatest; B) 2020 National Center for Environmental Information grid; and C) Difference plot between 2013 and 2020 grids (absolute values).
Figure 2 (cont.). Selected cross sections that highlight cross-shore differences in the model grids at D) Tillamook 5; E) Tillamook 8; and F) Tillamook 11.
Figure 3. Digital elevation model changes determined for Clatsop County.

A) Original 2013 model grid with yellow polygon that defines the region where the bathymetric error is greatest; B) 2020 National Center for Environmental Information grid; and C) Difference plot between 2013 and 2020 grids (absolute values).
Figure 3 (cont.). Selected cross sections that highlight cross-shore differences in the model grids at D) Clatsop 3; E) Clatsop 6; and F) Clatsop 8.
3.0 RESULTS

This section describes the changes identified from the revised tsunami inundation modeling. Here we will report on the observed differences for select areas along the coastline of Tillamook and Clatsop counties. Table 1 defines various color schemes used to differentiate areas having experienced no change in modeled tsunami inundation, areas subject to new inundation, and those areas now removed from tsunami inundation. For the distant (AKmax) tsunami inundation scenario, we use hatch markings (Table 1) to define the following categories: no change = hatch steel blue; now inundated = hatch magenta; and removed from inundation = hatch turquoise. For the local (XXL) tsunami inundation scenario, we use solid colors (Table 1) to define the same categories: no change = steel blue; now inundated = magenta; and removed from inundation = turquoise.

Table 1. Color scheme used to differentiate areas that have experienced no change in modeled tsunami inundation, have new inundation, or are removed from tsunami inundation for the AKmax distant (hatch markings) and XXL local (solid colors) scenarios.

<table>
<thead>
<tr>
<th>AKmax Distant Scenario</th>
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<tbody>
<tr>
<td>Hatch steel blue</td>
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<tr>
<td>Hatch magenta</td>
</tr>
<tr>
<td>Hatch turquoise</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>XXL Local Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>steel blue</td>
</tr>
<tr>
<td>magenta</td>
</tr>
<tr>
<td>turquoise</td>
</tr>
</tbody>
</table>

3.1 Tsunami Inundation Changes in Tillamook County

Figures 4 to 15 show a series of maps along the coastline of Tillamook County that depict the changes identified in our revised tsunami inundation modeling when compared with the original 2013 results.

3.1.1 Nehalem Valley

Tsunami inundation changes for the upper Nehalem Valley, which includes Nehalem and Mohler, are provided in Error! Reference source not found.. Overall, we see greater flooding (hatch magenta) associated with the distant tsunami scenario in the upper Nehalem Valley, particularly in areas east of Nehalem and farther upriver north of McDonald Rd. For the maximum-considered local scenario, areas now flooded are largely confined to the upper reaches of the Nehalem Valley and upriver (east) of Mohler (Error! Reference source not found.). Although not visible in Error! Reference source not found., the revised modeling indicates slightly greater flooding of the Nehalem community for both the distant and local scenarios. Changes in the community of Wheeler are generally negligible. Overall, greater flooding observed throughout the Nehalem Estuary can be directly attributed to improved bathymetry as well as better delineation of levees and river channels within the estuary.
3.1.2 Rockaway Beach, Barview, and Garibaldi

Figure 6. Tsunami inundation modeling changes defined for Twin Rocks, Barview, and Garibaldi. MHW shoreline denotes the Mean High Water shoreline elevation contour.

is of the Rockaway Beach area, which also includes Nedonna Beach in the north. Major changes in this section of the coast are largely confined to the distant AKmax scenario. As can be seen from the figure, for the distant event, several areas are now removed from tsunami inundation. These include portions of Nedonna Beach in the north adjacent to the Nehalem jetty and estuary mouth where significant dune
growth has occurred in recent years (Allan, 2020) that has now reduced the potential for tsunami inundation from a distant event. Similarly, Lake Lytle is now removed from the distant tsunami inundation zone. For the XXL local tsunami, differences between the 2013 and 2021 inundation modeling are generally negligible, with the 2021 results showing slightly less inundation along the edge of the hills.

Tsunami inundation changes at Twin Rocks, Barview, and Garibaldi are provided in Error! Reference source not found.. There is a slight increase in inundation associated with the XXL local scenario along the eastern edge of Twin Rocks. Of note there: Two “assembly area” sites are now located within the tsunami zone and will need to be reevaluated. At Barview, new modeling results for the distant tsunami event indicate several areas that will now be removed from flooding. These removals are mainly concentrated along the primary frontal foredune and within the estuary. Farther south, our latest modeling indicates greater flooding from a distant event along the tip of Bayocean Spit. At Garibaldi, the new modeling shows the distant tsunami event inundating a larger portion of the port docks by S 7th St. (Error! Reference source not found.). In contrast, for the local CSZ scenario, there is slightly less inundation west of the fire station determined in the new modeling.

Tsunami inundation changes for the upper Nehalem Valley, which includes Nehalem and Mohler, are provided in Error! Reference source not found.. Overall, we see greater flooding (hatch magenta) associated with the distant tsunami scenario in the upper Nehalem Valley, particularly in areas east of Nehalem and farther upriver north of McDonald Rd. For the maximum-considered local scenario, areas now flooded are largely confined to the upper reaches of the Nehalem Valley and upriver (east) of Mohler (Error! Reference source not found.). Although not visible in Error! Reference source not found., the revised modeling indicates slightly greater flooding of the Nehalem community for both the distant and local scenarios. Changes in the community of Wheeler are generally negligible. Overall, greater flooding observed throughout the Nehalem Estuary can be directly attributed to improved bathymetry as well as better delineation of levees and river channels within the estuary.
Figure 5. Tsunami inundation modeling changes defined for Nehalem, Mohler, and the upper Nehalem Valley. MHW shoreline denotes the Mean High Water shoreline elevation contour.

3.1.3 Rockaway Beach, Barview, and Garibaldi

Figure 6. Tsunami inundation modeling changes defined for Twin Rocks, Barview, and Garibaldi. MHW shoreline denotes the Mean High Water shoreline elevation contour.

is of the Rockaway Beach area, which also includes Nedonna Beach in the north. Major changes in this section of the coast are largely confined to the distant AKmax scenario. As can be seen from the figure, for the distant event, several areas are now removed from tsunami inundation. These include portions of Nedonna Beach in the north adjacent to the Nehalem jetty and estuary mouth where significant dune growth has occurred in recent years (Allan, 2020) that has now reduced the potential for tsunami
Tsunami inundation modeling update for Tillamook and Clatsop Counties

Inundation from a distant event. Similarly, Lake Lytle is now removed from the distant tsunami inundation zone. For the XXL local tsunami, differences between the 2013 and 2021 inundation modeling are generally negligible, with the 2021 results showing slightly less inundation along the edge of the hills.

Tsunami inundation changes at Twin Rocks, Barview, and Garibaldi are provided in Error! Reference source not found.. There is a slight increase in inundation associated with the XXL local scenario along the eastern edge of Twin Rocks. Of note there: Two “assembly area” sites are now located within the tsunami zone and will need to be reevaluated. At Barview, new modeling results for the distant tsunami event indicate several areas that will now be removed from flooding. These removals are mainly concentrated along the primary frontal foredune and within the estuary. Farther south, our latest modeling indicates greater flooding from a distant event along the tip of Bayocean Spit. At Garibaldi, the new modeling shows the distant tsunami event inundating a larger portion of the port docks by S 7th St. (Error! Reference source not found.). In contrast, for the local CSZ scenario, there is slightly less inundation west of the fire station determined in the new modeling.

Tsunami inundation changes for the upper Nehalem Valley, which includes Nehalem and Mohler, are provided in Error! Reference source not found.. Overall, we see greater flooding (hatch magenta) associated with the distant tsunami scenario in the upper Nehalem Valley, particularly in areas east of Nehalem and farther upriver north of McDonald Rd. For the maximum-considered local scenario, areas now flooded are largely confined to the upper reaches of the Nehalem Valley and upriver (east) of Mohler (Error! Reference source not found.). Although not visible in Error! Reference source not found., the revised modeling indicates slightly greater flooding of the Nehalem community for both the distant and local scenarios. Changes in the community of Wheeler are generally negligible. Overall, greater flooding observed throughout the Nehalem Estuary can be directly attributed to improved bathymetry as well as better delineation of levees and river channels within the estuary.
3.1.4 Rockaway Beach, Barview, and Garibaldi

Figure 6. Tsunami inundation modeling changes defined for Twin Rocks, Barview, and Garibaldi. MHW shoreline denotes the Mean High Water shoreline elevation contour.

is of the Rockaway Beach area, which also includes Nedonna Beach in the north. Major changes in this section of the coast are largely confined to the distant AKmax scenario. As can be seen from the figure, for the distant event, several areas are now removed from tsunami inundation. These include portions of Nedonna Beach in the north adjacent to the Nehalem jetty and estuary mouth where significant dune growth has occurred in recent years (Allan, 2020) that has now reduced the potential for tsunami
inundation from a distant event. Similarly, Lake Lytle is now removed from the distant tsunami inundation zone. For the XXL local tsunami, differences between the 2013 and 2021 inundation modeling are generally negligible, with the 2021 results showing slightly less inundation along the edge of the hills.

Tsunami inundation changes at Twin Rocks, Barview, and Garibaldi are provided in [Error! Reference source not found.]. There is a slight increase in inundation associated with the XXL local scenario along the eastern edge of Twin Rocks. Of note there: Two “assembly area” sites are now located within the tsunami zone and will need to be reevaluated. At Barview, new modeling results for the distant tsunami event indicate several areas that will now be removed from flooding. These removals are mainly concentrated along the primary frontal foredune and within the estuary. Farther south, our latest modeling indicates greater flooding from a distant event along the tip of Bayocean Spit. At Garibaldi, the new modeling shows the distant tsunami event inundating a larger portion of the port docks by S 7th St. ([Error! Reference source not found.]. In contrast, for the local CSZ scenario, there is slightly less inundation west of the fire station determined in the new modeling.)
Figure 4. Tsunami inundation modeling changes defined for Manzanita, Nehalem State Park, Bayside Gardens, and Nehalem. MHW shoreline denotes the Mean High Water shoreline elevation contour.
Tsunami inundation modeling changes for the upper Nehalem Valley, which includes Nehalem and Mohler, are provided in Error! Reference source not found.. Overall, we see greater flooding (hatch magenta) associated with the distant tsunami scenario in the upper Nehalem Valley, particularly in areas east of Nehalem and farther upriver north of McDonald Rd. For the maximum-considered local scenario, areas now flooded are largely confined to the upper reaches of the Nehalem Valley and upriver (east) of Mohler (Error! Reference source not found.). Although not visible in Error! Reference source not found., the revised modeling indicates slightly greater flooding of the Nehalem community for both the distant and local scenarios. Changes in the community of Wheeler are generally negligible. Overall, greater flooding observed throughout the Nehalem Estuary can be directly attributed to improved bathymetry as well as better delineation of levees and river channels within the estuary.
3.1.5 Rockaway Beach, Barview, and Garibaldi

Figure 6. Tsunami inundation modeling changes defined for Twin Rocks, Barview, and Garibaldi. MHW shoreline denotes the Mean High Water shoreline elevation contour.

is of the Rockaway Beach area, which also includes Nedonna Beach in the north. Major changes in this section of the coast are largely confined to the distant AKmax scenario. As can be seen from the figure, for the distant event, several areas are now removed from tsunami inundation. These include portions of Nedonna Beach in the north adjacent to the Nehalem jetty and estuary mouth where significant dune growth has occurred in recent years (Allan, 2020) that has now reduced the potential for tsunami
inundation from a distant event. Similarly, Lake Lytle is now removed from the distant tsunami inundation zone. For the XXL local tsunami, differences between the 2013 and 2021 inundation modeling are generally negligible, with the 2021 results showing slightly less inundation along the edge of the hills.

Tsunami inundation changes at Twin Rocks, Barview, and Garibaldi are provided in Error! Reference source not found.. There is a slight increase in inundation associated with the XXL local scenario along the eastern edge of Twin Rocks. Of note there: Two “assembly area” sites are now located within the tsunami zone and will need to be reevaluated. At Barview, new modeling results for the distant tsunami event indicate several areas that will now be removed from flooding. These removals are mainly concentrated along the primary frontal foredune and within the estuary. Farther south, our latest modeling indicates greater flooding from a distant event along the tip of Bayocean Spit. At Garibaldi, the new modeling shows the distant tsunami event inundating a larger portion of the port docks by S 7th St. (Error! Reference source not found.). In contrast, for the local CSZ scenario, there is slightly less inundation west of the fire station determined in the new modeling.
Figure 6. Tsunami inundation modeling changes defined for Twin Rocks, Barview, and Garibaldi. MHW shoreline denotes the Mean High Water shoreline elevation contour.
3.1.6 Bay City

Tsunami inundation changes in the Bay City area show more substantive changes, especially for the local CSZ tsunami inundation scenario (Error! Reference source not found.). The new tsunami simulations result in a number of areas being removed from the inundation zone (turquoise), especially east of 5th St. in Bay City and up along the Kilchis River Rd. For the distant tsunami scenario, the revised modeling indicates slightly greater inundation (hatch magenta), especially in the vicinity of the Kilchis River.

Figure 7. Tsunami inundation modeling changes defined for Bay City.
3.1.7 North Tillamook

Error! Reference source not found. is of the area north of the City of Tillamook. Overall, we see slightly greater flooding associated with the distant tsunami scenario along the periphery of the estuary (hatch magenta), and up the various creeks and river channels. Conversely, for the maximum-considered local (XXL) scenario, the latest modeling indicates that significant areas up the Kilchis River Valley, along Highway 101 by Suppress Rd., and east of N. Main Ave. (Highway 101) are now removed from flooding (Error! Reference source not found., turquoise).
3.1.8 City of Tillamook

The latest modeling results for the City of Tillamook and its surrounding area indicate substantive changes in both the distant and local tsunami inundation zones (Error! Reference source not found.). The latest modeling indicates greater flooding (hatch magenta) associated with the distant tsunami inundation scenario, with the inundation extending significantly farther upriver in all areas. These changes are entirely due to better delineation of the estuary channels, levees, and low-lying areas adjacent to the
Tillamook Estuary. Conversely, for the XXL local scenario, our latest modeling indicates that a significant portion of the western end of Tillamook (adjacent to the hospital) is now removed from tsunami flooding (Error! Reference source not found., turquoise). Areas removed from local (XXL) tsunami flooding are also evident for all distal parts of the inundation zone. Changes to the local tsunami zone are most likely a function of removal of a topographic mound off the coast, better delineation of the nearshore bathymetry, and possibly aggradation (vertical growth) of sand along the dunes of Bayocean Spit over the past 10 years (e.g., Allan, 2020; morphological changes in foredune growth along the Tillamook coast over the past two decades may also be found at: http://nvs.nanoos.org/BeachMapping).
Figure 9. Tsunami inundation modeling changes defined for the City of Tillamook.
3.1.9 Cape Meares

Modeled tsunami inundation changes in the community of Cape Meares are presented in Error! Reference source not found.. For the distant source tsunami (AKmax), our revised modeling indicates slightly less inundation along Bayocean Spit (hatch turquoise), which is likely due to growth in the foredune along the spit (Allan, 2020). Conversely, for the XXL local scenario, the latest modeling suggests slightly greater inundation (Error! Reference source not found., magenta).

Figure 10. Tsunami inundation modeling changes defined for the Cape Meares community. MHW shoreline denotes the Mean High Water shoreline elevation contour.
3.1.10 Netarts

Modeled tsunami inundation changes in the Netarts area show substantive changes for both the distant (AKmax) and local (XXL) tsunami inundation scenarios. The latest simulations produce greater inundation associated with the distant scenario, with many low-lying areas adjacent to creeks and wetlands east of Netarts Bay Rd. potentially inundated (hatch magenta). For the XXL local scenario, the revised modeling indicates additional inundation (magenta) adjacent to Crab Ave. (near the fire station), Netarts Boat Basin Rd., and Silver Sands St. Conversely, the revised modeling indicates less inundation farther up the estuary.

Figure 11. Tsunami inundation modeling changes defined for the Netarts community. MHW shoreline denotes the Mean High Water shoreline elevation contour.
3.1.11 Sand Lake Estuary

Modeled tsunami inundation changes in the Sand Lake Estuary are presented in Error! Reference source not found.. Changes associated with the distant source tsunami are relatively minor, with slightly greater inundation within the estuary (hatch magenta). Conversely, for the local CSZ scenario, the revised modeling indicates less inundation at the north end of the estuary (turquoise) and slightly increased inundation along the eastern edge of the estuary (magenta).

Figure 12. Tsunami inundation modeling changes defined for the Sand Lake Estuary. MHW shoreline denotes the Mean High Water shoreline elevation contour.
3.1.12 Pacific City

Error! Reference source not found. presents tsunami inundation changes identified for the community of Pacific City. For the distant earthquake scenario, the revised modeling indicates slightly less inundation along the open coast (hatch turquoise). This is likely due to recent accumulation of sand within the primary foredune (e.g., Allan, 2020; morphological changes in foredune growth along the Tillamook coast over the past two decades may also be found at: http://nvs.nanoos.org/BeachMapping). However, within the Nestucca Estuary, our revised modeling indicates more substantial flooding (hatch magenta) (Error! Reference source not found.), with many new areas within Pacific City now impacted (e.g., Rueppell Ave. and along Brooten Ave.). Such changes are probably related to improved delineation of the estuary bathymetry, including the ebb-flood tidal channels. Conversely, for the XXL local scenario, the revised modeling indicates negligible change, and is not surprising since improvements to the DEM along this part of the coast were negligible.
Figure 13. Tsunami inundation modeling changes defined for Pacific City. MHW shoreline denotes the Mean High Water shoreline elevation contour.

3.1.13 Neskowin

Error! Reference source not found. presents inundation changes identified for the Neskowin area. The updated modeling indicates greater inundation caused by the distant tsunami scenario in the vicinity of north Neskowin (hatch magenta) and in the south along Neskowin Creek (Error! Reference source not found.). Conversely, the revised modeling indicates virtually no change to the maximum-considered local (XXL) scenario.
3.2 Tsunami Inundation Changes in Clatsop County

Figures 16 to 20 present a series of maps for Clatsop County that depict the changes identified in our revised tsunami inundation modeling when compared with the original 2013 results. As with the Tillamook County maps, Table 1 defines the various color schemes used to differentiate areas with no
modeled change in tsunami inundation, areas subject to new inundation, and those areas now removed from tsunami inundation. For the distant (AKmax) tsunami inundation scenario, we use hatch markings (Table 1) to define the following categories: no change = hatch steel blue; now inundated = hatch magenta; and removed from inundation = hatch turquoise. For the local (XXL) tsunami inundation scenario, we use solid colors (Table 1) to define the same categories: no change = steel blue; now inundated = magenta; and removed from inundation = turquoise.

3.2.1 Warrenton

Modeled tsunami inundation changes in the Warrenton area are presented in Error! Reference source not found. Changes associated with distant source tsunamis are relatively minor, with the latest modeling indicating slightly less inundation in various low-lying areas of Warrenton (hatch turquoise, Error! Reference source not found.). Conversely, for the XXL local scenario, the revised modeling indicates a variety of changes, including slightly greater inundation near Oak Ave., north of Camp Rilea (magenta, Error! Reference source not found.), and less inundation adjacent to Fort Stevens State Park.
Figure 15. Tsunami inundation modeling changes defined for the Warrenton area. MHW shoreline denotes the Mean High Water shoreline elevation contour.
3.2.2 Central Clatsop Plains

For the central Clatsop Plains (Error! Reference source not found.), our analyses indicate that differences between the latest and original modeling are negligible for the distant source tsunami (AKmax). This is likely due to the height and width of the primary foredune along the Clatsop Plains, which have been steadily aggrading vertically over the past few decades (Allan and others, 2015). For the maximum-considered XXL local scenario, our revised modeling indicates that a number of areas adjacent to Sunset Beach Ln. and Highway 101 are now removed from the tsunami inundation zone (turquoise, Error! Reference source not found.). Increased flooding (magenta) from the local tsunami inundation scenario is mainly confined to areas along the edge of the coast hills in the east.

Figure 16. Tsunami inundation modeling changes defined for the central Clatsop Plains. MHW shoreline denotes the Mean High Water shoreline elevation contour.
3.2.3 Gearhart

Error! Reference source not found. presents the tsunami modeling changes for the community of Gearhart. Overall, the latest modeling indicates much greater inundation associated with the maximum-considered distant tsunami scenario (hatch magenta, Error! Reference source not found.). This is especially the case east of Highway 101 and within two low-lying areas adjacent to Summit Ave. in central Gearhart. Changes associated with the XXL local tsunami are negligible.

Figure 17. Tsunami inundation modeling changes defined for Gearhart. MHW shoreline denotes the Mean High Water shoreline elevation contour.
3.2.4 Seaside

Modeled tsunami inundation changes in the Seaside area are presented in Error! Reference source not found. For the distant scenario, the revised modeling indicates substantive changes throughout the area. It indicates much less inundation (hatch turquoise) for the distant tsunami along much of the western edge of town (i.e., west of Highway 101 along the Promenade, Error! Reference source not found.), but greater inundation along the eastern edge of town (Error! Reference source not found.). Changes associated with local Cascadia source tsunami are negligible.
3.2.5 Cannon Beach

Finally, Error! Reference source not found. presents the tsunami modeling changes for the community of Cannon Beach. The latest modeling indicates generally less inundation associated with the maximum-considered distant tsunami scenario (hatch turquoise, Error! Reference source not found.). This is especially the case in the vicinity of Ecola Creek and in several areas near Tolovana Beach. Changes associated with the XXL tsunami model are negligible.
4.0 UPDATED STATEWIDE TSUNAMI EVACUATION LAYER

With the completion of the revised tsunami inundation simulations for Tillamook and Clatsop counties presented here, accompanied by discussions with emergency managers in both counties, the
recommendation from the County emergency managers was to proceed with adopting the revised tsunami inundation maps in both counties. Accordingly, we have incorporated these results into a new updated statewide tsunami evacuation inundation zone (http://nvs.nanoos.org/TsunamiEvac). In addition to the changes presented here for Tillamook and Clatsop counties, we also incorporated new tsunami inundation modeling results—for both the distant (AKmax) and local (XXL) inundation zones—from Allan and others (2018) for the Columbia River system, which are described further here.

4.1 Columbia River Tsunami Modeling

Between 2016 and 2018, Allan and others (2018) completed new tsunami inundation modeling for both distant (AK64 and AKmax) and local (L and XXL) scenarios for the Columbia River system. The study extended from the mouth of the Columbia River upriver to Bonneville Dam; previous modeling undertaken by Priest and others (2013) ended just east of Tongue Point in Astoria. Hence, the updated modeling of Allan and others (2018) reflected tsunami inundation results that covered both the States of Washington and Oregon and was a collaboration between DOGAMI, the Washington Geological Survey (WGS) and the Washington State Department of Natural Resources.

After consulting with emergency managers in Clatsop and Columbia counties, the decision was made to incorporate the tsunami modeling results of Allan and others (2018) into the revised statewide tsunami inundation layer. Discussions were also had with WGS to determine which local Cascadia scenario (L or XXL) they preferred to use for the Washington side of the Columbia River, and whether they would adopt the maximum-considered (AKmax) distant scenario. For inundation along the Washington side of the Columbia River, WGS requested the Run05c-L1 scenario, which is based on the L1 tsunami inundation scenario simulated at mean high water with no river flow and a bottom roughness (friction) factor of n=0.025 (Table 1 in Allan and others, 2018, p12). For the distant scenario, the WGS agreed with the approach of DOGAMI, which was based on an ensemble AKmax inundation product.

Allan and others (2018) performed multiple tsunami simulations for the Columbia River using both static (fixed tide stage) and dynamic (fluctuating) tidal modeling with the tsunami timed to arrive at specific tidal stages (flood, ebb, slack, spring, and neap), and with different river discharge rates (no discharge and average, high, and low discharge). The purpose was to better understand the nonlinear relationship among the tsunami, tidal currents, and river discharge in both reducing and enhancing a tsunami as it travels up the Columbia River. This contrasts with the approach used by Priest and others (2013) where tsunami modeling along the open coast was performed using a fixed (static) tide at MHHW. After evaluating the suite of inundation results obtained for the Columbia River, Allan and others (2018) settled on an ensemble inundation product that reflected the maximum inundation associated with six (Run05, Run06, Run07, Run08, Run09, Run12) out of eight of the possible model scenarios. Two model simulations that evaluated tsunamis arriving at high and low river discharge flows were excluded from consideration since the joint probabilities of an XXL, L, or AKmax tsunami and high/low river discharge were determined to be extremely unlikely. The decision to use results from six different XXL and AKmax tsunami/tide scenarios was based on the fact that there are important nonlinear responses among the tsunami, tidal stage, and tidal current, plus river flows with distance up the Columbia River. Thus, upriver locations are influenced by much later-arriving tsunamis that are strongly dependent on the tidal stage, resulting in maximum inundation at very different times of the tidal cycle, when compared with modeling using a static (fixed) tide stage as used along the open coast.

Revised tsunami evacuation brochures have since been produced for both Tillamook and Clatsop counties and are available through the Oregon Tsunami Clearinghouse (oregontsunami.org) and via the
online tsunami evacuation portal (http://nvs.nanoos.org/TsunamiEvac) hosted by the NANOOS. At this stage we have not yet developed dedicated tsunami evacuation maps for Oregon communities along the Columbia River. Nevertheless, inundation results associated with a maximum-considered distant (AKmax) and local Cascadia (XXL – Oregon, and L1-Washington) tsunami now cover the Columbia River system and are available via the NANOOS tsunami evacuation portal and smartphone application, NVS Tsunami (http://www.nanoos.org/mobile/tsunami_evac_app.php).

5.0 SUMMARY

The objective of this report has been to document updated tsunami inundation simulations undertaken for both a maximum-considered Eastern Aleutian (distant) and CSZ earthquake (local) originally modeled for Clatsop and Tillamook counties by Priest and others (2013). The need for revised tsunami inundation simulations in both counties was due to the discovery of bathymetric errors in the original model grids. Hence, this study corrects for those errors and describes differences between the original and revised modeling.

With the completion of updated tsunami inundation simulations for Tillamook and Clatsop counties, and following discussions with local emergency managers, the recommendation from both County Emergency Managers was to proceed with adopting the revised tsunami inundation maps in both counties, as well as in Columbia County to reflect new modeling results from Allan and others (2018). These changes have been implemented and revised tsunami evacuation brochures are now available through the Oregon Tsunami Clearinghouse (oregontsunami.org), while updated tsunami evacuation zones have been incorporated in the online tsunami evacuation portal (http://nvs.nanoos.org/TsunamiEvac) hosted by NANOOS.

6.0 ACKNOWLEDGMENTS

This project was funded under award #NA19NWS4670013 by National Oceanic and Atmospheric Administration (NOAA) through the National Tsunami Hazard Mitigation Program. Simulations used in this paper were conducted using the following computational facilities: 1) SciClone at the College of William and Mary, which was provided with assistance from the National Science Foundation, the Virginia Port Authority, Virginia’s Commonwealth Technology Research Fund, and the Office of Naval Research; 2) the Extreme Science and Engineering Discovery Environment (XSEDE; grant TG-OCE130032), which is supported by National Science Foundation grant number OCI-1053575; and 3) NASA’s Pleiades supercomputer. Finally, we thank Jason McClaughry of DOGAMI for his thorough and constructive review comments.
7.0 REFERENCES


